

Personnel Identification System Utilizing Low Probability of Intercept Techniques for Covert Operations

David J. Chiang
U.S. Army CECOM-NVESD
AMSEL-RD-NV-SR-R, Fort Monmouth, NJ 07703-5206

Michael C. Zari, Chris S. Anderson, Anthony F. Zwilling, Joe W. Fikes
Dynetics, Inc.
1000 Explorer Blvd, Huntsville, AL 35806-2800

David A. Hess, Reeder N. Ward
Harris Corporation
P.O. Box 98000, Melbourne, FL 32902-9800

ABSTRACT

This paper documents the design of a Laser / RF Personnel Identification (ID) System developed by the US Army CECOM and the Dynetics Corporation. The ID System includes an eye safe Laser Interrogation Unit with a programmable activation code. The Interrogation Unit is very directive for low probability of intercept (LPI) which is of interest during covert operations. A Responder Unit is worn by the soldier and transmits a LPI RF response centered at 900 MHz, only after receiving the proper interrogation code. The basic subsystems for the identification system are a Laser Interrogation Unit, a RF Responder Unit, and an electronic Programming / Synchronization Unit. The operating principles for the subsystem are reviewed and the design issues are discussed. In addition to the design performed under Phase I of the program, a breadboard system was developed to validate the proof of principle concept. Hardware implementation is reviewed and field testing of the breadboard is presented. The Phase II development, engineering plans, and preliminary results are also presented.

The military application of this system is evident through the official reports of fratricide experienced both in the Gulf War and more recently, in military overseas operations in countries with heavily armed indigenous inhabitants. Fratricide represents an unacceptable political risk for US peacekeeping operations. Military users of the system potentially include all ground based as well as some other combat forces. Other military and civilian users will depend on the Laser / RF Identification technology being developed under the current Phase II effort. This includes the Dual-Use need for a long range (1-km), highly reliable, non-voice, and non-spatial resolution based ID technique for restricted area protection. Commercial users would benefit from this dual use development in the areas of law enforcement, motor vehicle identification, and intrusion systems. As an example of the concept's versatility, the system can be applied commercially in law enforcement to perform remote vehicle identification without visual contact with the license plate number.

Although their applications differ drastically, military and commercial users require similar product features, indicating a need for increased manufacturing and lower costs. The development of the laser interrogator with a RF response is a low cost solution to extremely important security issues.

1. SYSTEM CONCEPT AND PRELIMINARY SPECIFICATIONS

Figure 1 illustrates the *Soldier Identification System* concept. In operation, the Interrogation Unit transmits a highly directive, encoded laser burst to an unknown person (ie target) at ranges in excess of 2 km. Simultaneously, a spread spectrum RF code is transmitted by the Interrogation Unit for additional verification and security. The Responder Unit detects both the modulated optical and RF signals. Upon verification that a valid interrogation has been made, the Responder Unit transmits a low probability of intercept (LPI) spread spectrum RF response.

The Interrogation Unit expects a response during a specified time window. Upon verification that a valid RF response has been received, indicators (both audio and tactile) on the Interrogation Unit alert the gunner to the status of the interrogation. The interrogation and response codes are programmable to allow for "code of the day" operation, and the codes can be changed automatically at, for example, 12 hour intervals in all Interrogation and Responder Units. This feature helps defeat undesirable playback of captured codes.

Table 1 lists the operational specifications for the *Soldier Identification System*. Operating platforms are given for the Interrogation Unit, and the designed platform for the Responder Unit is the field soldier. Since power, size, and weight were minimized during design, the Responder Unit can be easily adapted to vehicle platforms, ie. Armored personnel carriers (APCs). Characteristics for the Prototype Interrogation are shown in **Figure 2**. As noted in the figure, the prototype system includes visible and infrared aiming lasers compatible with Army nightvision devices. It should be noted that the aiming lasers are not required for the interrogation function.

Table 1. Prototype Soldier ID Specifications

Parameters	Prototype Specifications
Maximum Range ID (P=0.90 %)	2000 meters
Minimum Range ID (P=0.90 %)	0.25 meters
Interrogation Angular Resolution * (mrad)	10
Maximum Interrogation Time (sec)	1.0
Eyesafe Operation of Laser	Yes
Low Probability of Intercept (LPI)	Yes
Day / Night Operation	Yes

*Note: Angular Resolution can easily be modified to suit operational requirements.

2. PROTOTYPE DESIGN ISSUES

2.1 Interrogation Unit

Key subsystem components of the Interrogation Unit include the laser transmitter, the spread spectrum RF transceiver, code processor/controller, and the interrogation activation switch. To meet the goals/requirements for this interpersonnel communication system, many design issues have been addressed, including the selection of laser characteristics (wavelength, beam size, and power), interrogation code generation for LPI, and RF transmitter and receiver characteristics that meet LPI, range, and low power consumption requirements.

2.1.1 Optical Considerations

During an interrogation cycle, the interrogation laser diode is modulated with a specific code, which in turn causes the laser diode to emit laser light in the same code. The light is radiated from the laser diode typically at a high divergence angle (ie. 40 degrees) and must be collimated by a lens to the divergence required for achieving operational resolution. Thus, the laser diode and lens assembly produces a nearly collimated (ie. 10 mrad divergence) optical beam that is used to optically interrogate the target.

There were many key considerations in designing the optical system, including wavelength selection of the interrogation laser, eye safety, optical power to meet system range requirements, laser diode output characteristics, availability of commercial off the shelf components (COTS), and operational environment. Solar radiation about the interrogation laser wavelength, and the detection of the optical interrogation signals by current nightvision equipment were also considered.

A design spreadsheet was developed to compare performance tradeoffs between different optical system component combinations. The spreadsheet includes inputs on the laser parameters, interrogation code specifics, the system operational scenario, and optical receiver parameters. Calculations include signal levels at minimum and maximum ranges, contributions due to solar irradiance, signal variations at range limits, receiver noise terms, and the potential signal to noise ratio (SNR) (at maximum range) based on single pulse detection. In addition, eye safety calculations are performed in the spreadsheet based on code duration, wavelength, power, etc. These calculations are used to determine if the laser interrogation follows ANSI standards for eye safety and maximum permissible exposure (MPE).

2.1.2 RF Considerations

In addition to the laser interrogation code, a second interrogation code is modulated and transmitted from the Interrogation Unit to the Responder Unit via a RF transmitter. In this sense, the RF code provides an omnidirectional interrogation. For this dual mode laser/RF *Soldier Identification System*, the laser portion of the interrogation system provides directional selectivity while the RF interrogation provides additional

security. Note that directionality of the RF interrogation can be achieved at the expense of increased size, weight, and cost.

As with the optical system, there are many considerations in designing the RF system, including frequency selection, RF power to meet system range requirements, LPI considerations, availability of COTS components, and operational scenario. Desirable features for the RF transceiver system include compact size, low power consumption, battery operation, reprogrammability, and sleep mode operation.

Given the operational environment and requirements placed on the system, spread spectrum technology has been selected for the prototype *Soldier Identification System* testing and demonstration. The spread spectrum modulation scheme for the RF portion of the communication system provides LPI of the interrogation/response codes in addition to interference rejection/suppression of both environmental and intentional sources. For the prototype system development, a frequency hopping, spread spectrum (FHSS) modulation scheme was utilized.

2.1.3 Weapon and User Interfaces

For the prototype *Soldier Identification System*, the Interrogation Unit mounts to the weapon (ie. M16-A2 platform) with the scope mount attachment. The weapon interface was designed so that the gunner can still use the M-16 weapon's metal sights for aiming. As mentioned, the attachment interface to the M-16 weapon can be modified to meet the application requirements. Interfaces are required for initiation of an interrogation cycle and to indicate the results of the interrogation to the gunner. Considerations for the interfaces include the system operational environment and ergonomics. A pressure switch located on the lower hand guard of the M19-A2 rifle activates the interrogation cycle. The individual gunner to suit ergonomic considerations can adjust the location of the switch. For the prototype *Soldier Identification System*, both audible and vibration indicators alert the gunner to the status of the interrogation. The selected indicator will have an output only if a "friend" response has been verified. An "unknown" response will be noted by the lack of an indicator output.

2.2 Responder Unit

At the Responder Unit, an optical detector assembly is used to detect the laser interrogation code. In addition, a RF transceiver is used to receive the RF interrogation code. When both of the received codes match the stored reference codes, an RF response code is sent from the Responder Unit. The RF response code will be transmitted via the FHSS transceiver on the Responder Unit. Back at the Interrogation Unit, the response code is detected and compared to the stored reference code for the proper response. Once the received RF code has been verified as a valid response, a signal is sent to the indicators (ie. LED and/or vibrator) on the Interrogation Unit indicating a "friend".

The Responder Unit is small, lightweight, and attaches to the soldier's uniform. The operation of the Responder Unit is completely transparent to the soldier or end user.

The transmitted interrogation signal is received via the infrared (IR) detectors that are attached to the soldier's uniform to provide a complete hemispherical field of view (FOV). The filtered detector package is connected to the optical front end portion of the Responder Unit via shielded cable. Design issues for the Responder Unit are similar to those of the Interrogation Unit with the additional requirement of withstanding the expected environment of the platform – the individual soldier in combat or training situations.

3. PROTOTYPE TESTING

Figure 4 shows the Prototype Interrogation Unit on a M16 platform. Key components, such as the interrogation laser/optics, FHSS transceiver, activation switch, and “friend” indicator are identified in the figure. Also noted in the figure are the end user boresight adjustments to align the prototype system with the weapon's metal sights. **Figure 5** shows the prototype Responder Unit components and the prototype system housed in a vest for prototype *Soldier Identification System* testing. Testing of the prototype *Soldier Identification System* was performed at the U.S. Army Infantry Center (USAIC) Dismounted Battlespace Battle Lab (DBBL) in Ft. Benning, Georgia, and at the Redstone Technical Test Center (RTTC) in Huntsville, Alabama.

3.1 Testing at USAIC DBBL

Prototype testing was performed at the DBBL (Figure 6) as part of the Concept Evaluation Program (CEP). A major objective of the CEP tests was to determine the performance parameters, under both benign and realistic conditions, of candidate combat identification (CID) technologies. The performance parameters evaluated during the test were based on a subset of the Combat Identification for Dismounted Soldiers (CIDDS) Operational Requirements Document (ORD) required capabilities. Parameters measured include probability of correct identification, interrogation resolution, and timeliness.

Testing was performed by the Government at Buckner Range and at Decker Strip at Ft. Benning, GA, under day and night conditions. Testing was performed at ranges out to 1375 meters which was the maximum line of sight (LOS) range available for the system testing. In addition, testing was performed with the gunner (Interrogation Unit) and target (Responder Unit) in various configurations and scenarios. Scenarios included the gunner in a stationary position (ie. Standing or prone) and target in either a stationary position (ie. Standing, kneeling, or prone) or moving (ie. Running through a wooded area). For the testing, the gunner aims the weapon and proceeds to interrogate the target a set number of times per each position. Data collection occurred for each set of tests, as shown in **Figure 6**. In addition, each set of tests was repeated with different personnel/gunners performing the interrogations. Also for the night tests, aiming of the Interrogation Unit was assisted by the IR aiming laser on the prototype system and with the use of night vision devices.

The *Soldier Identification System* prototype demonstrated a 90% probability of correct identification. The system was successfully tested during both day and night conditions out to the maximum available range of 1375 meters.

3.2 Testing at RTTC

Performance testing was also performed at the Redstone Technical Test Center (RTTC). The major objective of these tests was to determine range performance of the prototype system; to determine the probability of correct identification as a function of range. For the tests, the Interrogation Unit was mounted on a tripod and the Responder Unit was moved to various locations on the test area. For each test, the target remained in the standing position and was interrogated a set number of times, and the number of valid responses were noted. Based on the testing, the prototype *Soldier Identification System* was successfully tested to ranges in excess of 4000 meters. At a range of 3500 meters, the system successfully achieved a 90% probability of correct identification.

4. CONCLUSION

In summary, the prototype *Soldier Identification System* has resulted in a very compact, cost-effective solution that meets the dismounted soldier identification requirement. The innovative laser/RF concept feasibility was determined through design and simulation, and demonstrated through prototype system testing. Advantages of this approach include low cost, LPI, potential for range extension, and fast (<600 msec) interrogation decision times. The prototype *Soldier Identification System* was made available to the Government (USAIC DBBL) for evaluation by the military community under various combat test conditions. As a result of the extensive testing, the performance of the system surpassed the anticipated performance, achieving a 90% correct probability of identification to a range of 3500 meters.

REFERENCES

1. "New Electronic Device Developed to Prevent Friendly Fire Incidents", *Defense Electronics*, p. 12, March 1995
2. Cornelius, G., "U.S. Forces Seek Affordable Solutions to Combat Identification Problems", *Signal*, p. 71-73, September 1994.
3. "Joint Operational Requirements Document for the Combat Identification System".
4. "American National Standard for the Safe Use of Lasers", ANSI-Z136.1-1993.
5. Holmes, J.K., *Coherent Spread Spectrum Systems*, John Wiley & Sons, New York, 1982
6. Dixon, R.C., *Spread Spectrum Systems*, John Wiley & Sons, New York, 1982

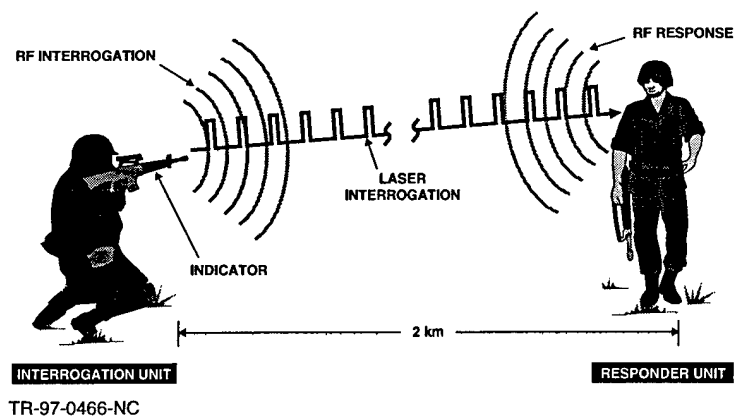


Figure 1. Laser/RF Soldier Identification System Concept

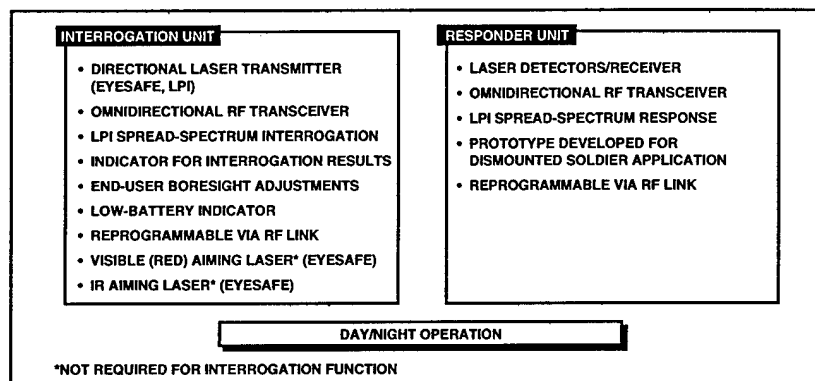


Figure 2. Prototype "Soldier Identification System" Characteristics

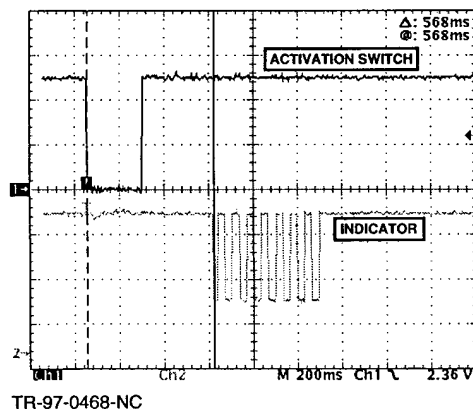
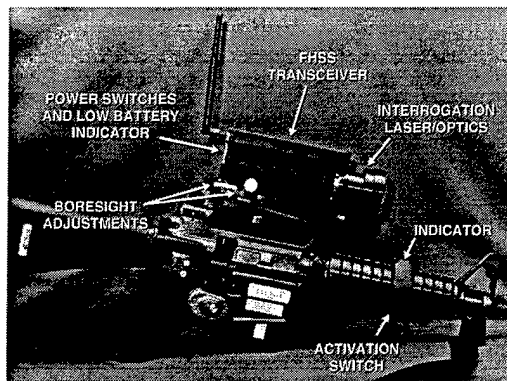
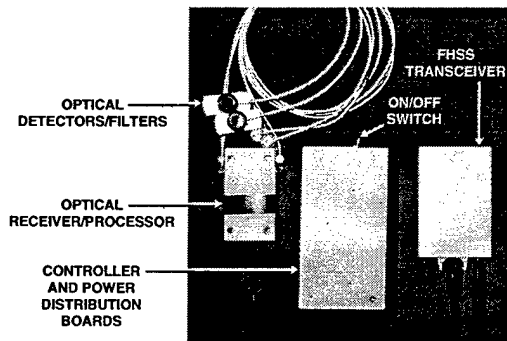


Figure 3. Breadboard Testing: Closed-Loop Interrogation Times



TR-97-0469-NC

Figure 4. Prototype Interrogation Unit on M16 Platform



(a) Components



(b) Vested-Housed Prototype

TR-97-0470-NC

Figure 5. Prototype Responder Unit



TR-97-0471-NC

Figure 6. Prototype "Soldier Identification System" Testing at DBBL